Cluster Based Energy Efficient Routing Protocol Using ANT Colony Optimization and Breadth First Search

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Abstract

This paper presents an algorithm to choose optimal path for data delivery for continuous monitoring of vital signs of patients in Body Area Network (BAN) in hospital indoor environments where a large number of patients exist and the traffic generated on the path rapidly changes over time. The methodology for finding the optimal path includes a meta-heuristic that combines ANT Colony Optimization (ACO) using Clustering. We propose a ACOBAN Clustering for monitoring BAN data and propose a method to improve network life, energy, load balancing on the overall network. Since traffic generated by BANs on the network changes with time, so the optimal path is important in Wireless Body Area Network. Our algorithm ensures network connectivity by using a mechanism of modified Cluster Head rotation process level by level and using breadth first search algorithm which avoids trapping during exploration. In the current work, we implemented ACO method and done experimental results on OMNeT++ to prove that the proposed method can find a better solution than conventional methods.

Keywords: ANT Colony; Clustering; OMNeT++; Optimization; WBAN.

1. Introduction

Ant colony optimization (ACO) is a meta-heuristic search algorithm for problem solving that takes the inspiration from the behaviours of real ants. The basic idea of ACO lies on the ants communicating among individuals in colonies based on the pheromone trails with other ants from source to destination in search of food. It has been a combinatorial optimization problem by Dorigo et al.1, and can be used for many applications including Wireless Sensor Network (WSN). Many studies on ACO have been performed using travelling salesman problem and have proven to be superior when compared with other meta-heuristic approaches. The network lifetime, energy efficient and reliability of data transmission are one of the most important criteria for WBANs. The sensor nodes work independently with limited resources like power supply and range of communication. The sensor nodes present in WBAN need to utilize it resources properly and participate in the network efficiently in order to meet their characteristics. Hence, optimizing the energy consumption of the sensor nodes as well as the reduce number of nodes participation increases the overall network is an important task when designing and routing of the sensitive and critical data of WBAN. Therefore, energy saving mechanism is done by choosing soft computing technique like ANT Colony Optimization which utilizes few
nodes participation such that optimal path is selected so that overall network lifetime is prolonged. Routing protocols play an important role in managing the energy consumption of the WBAN, where they define the path of transferring data packets from BANs to the destinations either MDCs or NSC as shown in Fig. 1. These routing protocols have to be design such a way that they save energy by establishing the route discovery by using minimum number of hops for efficient data transmission. Hence, only one technique can be incorporated for reduction of energy consumption by using data aggregation. Data aggregation helps the network to reduce the load on the nodes before transmission. We used cluster based routing protocols for data aggregation. This cluster based routing protocol is very prominent for its scalability. It organizes the sensor nodes into clusters where each cluster has a Cluster Head which is responsible of receiving and aggregating data from all other members in that cluster group. In order to have better operation, the cluster based routing protocol has to deal with the optimization in cluster formation and cluster head selection in order to achieve efficient data transmission to obtain high data throughput, reduce energy consumption and increased network life time. Many cluster based protocols have been proposed in the literature such as, they are unable to achieve optimal network organization during formation and selection. One prominent well-known one is LEACH that has been energy efficient protocol when compared with other conventional protocols. The clusters formed by LEACH are not inform because of the uneven distribution of sensor nodes in each clusters which results in high traffic load and fast energy depletion at the cluster heads. Improvement of these protocols is needed with support of novel optimization techniques for WBAN. In most of the BANs, when the communication range is limited, tree based routing protocol, it may require more than two intermediate nodes transfer data from source to destination. A tree-based routing protocol is used for multi-hop communication and also for data aggregation within the network which is the best way for energy conservation. Hence it reduces the communication burden on the network like WBAN network scenario where it corresponds to limited sources. Hence, the tree based routing protocol construction where selection of aggregation of nodes needs to be optimized in order to achieve high energy efficiency of data transferring. Energy consumption in the node is the main concern when designing the routing protocols of the WBANs to increase the network lifetime. An efficient reduced energy consumption routing protocols are needed to assist the operation effectively in better way.

Rest of the paper is organized as follow. Section 2 provides related work, section 3 explains about the motivation for the work. Section 4 explains the proposed technique. Section 5 shows the performance evaluation and results and finally in section 6 paper is concluded.

2. Related Work

Wireless Body Area Network (WBAN) have become a high impact on the health care because of ageing population due to its sedentary lifestyle and poor diet resulting in an increase in number of people with chronic disease which requires continuous monitoring of the patient. Wireless sensor network technology offers a large scale and cost-effective solutions to this problem. It has become necessity for providing the quality health care timely by using Wireless Body Area Network technology. Based on the IEEE 802.15.6 working group nodes, BANs communication
is based on hierarchical model with multiple tiers. The communication architecture consists of three tiers called BANC (Body Area Network Coordinator), MDC (Medical Display Coordinator) and NSC (Nursing Station Coordinator) as shown in Fig. 1. In tier 1, wearable or implanted sensors send data to the coordinator called BANC. In tier 2, the BANC data is sent to the peering MDC and in tier 3, all the centralized data is stored at NSC. In an indoor hospital scenario, every patient’s BAN needs a MDC for displaying patient’s data and finally to the NSC through effective means of routing. As discussed in for an indoor hospital scenario, it uses centralized and distributed mode of communicating the BAN data packets which are sensitive and critical packets. Communication of the data packets plays a vital role in WBAN, since it consumes energy of the sensor node and that can be optimized by finding the best route to address all important issues concern with latency, throughput and QoS.

The challenges pertaining to the management of patients medical data, an intelligent continuous monitoring of BAN data in hospital environment is discussed . Two communication tiers are used to send the data from body sensors to the base station in the projects. SMART provides a technique of monitoring system for indoor hospital environment but it covers only the emergency rooms. Body movement recognition using sensors is discussed in the literature. Security based assistance during hospitalization is addressed in. ALARM-NET proposed a solution for living and residential monitoring of patients. The purpose of this project is to collect and analyze BAN data at central base station. However the display of real time BAN data in indoor hospital environment is not been addressed using soft techniques. EPR addressed the energy consumption, QoS requirements for indoor hospital environment but not addressed the shortest path for routing data when traffic congestion or link failure occurs which can cause delay or stop displaying the patients data. Our proposed Cluster based ACO algorithm emphasis on the real-time display of BAN data using shortest path routing for different scenarios in the environment. Only centralized approach was used for monitoring the patients data but it failed to work for displaying the BAN data when there is no connectivity of BAN with central base station. Many researches proposed BAN network architecture by combining or splitting BAN in inter-BAN communication but they failed to address the real time display of BAN data in indoor hospital environment.

3. Motivation

In most of the BANs, when the communication range is limited, it may require more than two intermediate nodes to transfer data from source to destination. Energy consumption by the nodes is the main concern when designing routing protocols for the WBANs to increase the network lifetime. Existing protocols focus more on conventional techniques which may not give desired results. In this work, a tree-based routing protocol is used for multi-hop communication and also for data aggregation within the network which is the best way for energy conservation. The proposed protocol uses similar system model approach as discussed in ZEQoS and EPR routing protocols. We introduce a soft computing technique known as ACO for routing and compare its performance with the traditional technique. Additionally a cluster based approach is introduced by considering higher pheromones and energy residual by electing them level to level, to enhance the performance before its transmission to the destination. The propose method uses a minimum cost function value from routing table to select the optimal path from source to sink for any kind of packets to handle and shows better results in terms of reduced overhead, reduced number of packets forwarded by intermediate nodes and high rate of data transmission. For validating the performance of the proposed protocol, we have compared Cluster based ACO BAN with traditional techniques like ZK-BAN.


The proposed algorithm introduces a cluster formation within the network wherein each cluster MDCs will become the cluster head within its terrain and forms a cluster called caves. The nodes in each cluster send their data to the cluster head. The cluster heads send their aggregated data to the next cluster head. Reliable and sensitive data has to be transmitted to the destination to address the criticality of the patient at right time. Hence clusters are formed to forward only critical information to the destination rather sending continuous data. Whenever there is a need for emergency to be handled, the critical data has to transfer to the NSC for immediate treatment. Thus, such data can be transmitted timely through cluster heads within the network. We propose a modified probabilistic function to choose next cluster head level by level.
Table 1. Notations.

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>node identification in the current sensor network</td>
</tr>
<tr>
<td>p</td>
<td>percentage of selecting cluster heads</td>
</tr>
<tr>
<td>r</td>
<td>current round number</td>
</tr>
<tr>
<td>G</td>
<td>Set of nodes that havent elected as CH in the last rounds</td>
</tr>
<tr>
<td>$p^h_{\text{current}}$</td>
<td>Current pheromone values of the nodes</td>
</tr>
<tr>
<td>$p^h_{\text{initial}}$</td>
<td>Initial pheromone values of the nodes</td>
</tr>
<tr>
<td>$E_{\text{current}}$</td>
<td>Current energy of the node</td>
</tr>
<tr>
<td>$E_0$</td>
<td>Initial energy of the node</td>
</tr>
<tr>
<td>$\tau_{ij}$</td>
<td>Pheromone trail of combination (i, j)</td>
</tr>
<tr>
<td>$\eta_{ij}$</td>
<td>Local heuristic of combination (i, j)</td>
</tr>
<tr>
<td>$P_{ij}$</td>
<td>Transition probability of combination (i, j)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Relative importance of pheromone trail</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Relative importance of local heuristic</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Trail persistence</td>
</tr>
<tr>
<td>$q_0$</td>
<td>Determines the relative importance of exploitation versus exploration</td>
</tr>
<tr>
<td>$D_{ij}$</td>
<td>distance between the nodes (i, j)</td>
</tr>
<tr>
<td>$t_i$</td>
<td>type of the device</td>
</tr>
<tr>
<td>$\text{CostFunction} (i, j)$</td>
<td>Cost function from source node to destination i.e. (i,j)</td>
</tr>
<tr>
<td>$\text{Seqnum}$</td>
<td>Sequence number</td>
</tr>
<tr>
<td>$\text{Ant}_\text{-visitednode}$</td>
<td>Ants visited nodes list</td>
</tr>
<tr>
<td>TTL</td>
<td>Time to Live</td>
</tr>
<tr>
<td>$\text{BAN ID}_{-i}$</td>
<td>Source node BAN ID</td>
</tr>
<tr>
<td>Hops count</td>
<td>Hops count</td>
</tr>
<tr>
<td>Lastupdate time</td>
<td>Lastupdate time</td>
</tr>
</tbody>
</table>

Link failure is a common occurrence in Wireless Body Area Networks, due to its connectivity on the body in order to monitor the physical parameters of the patients in the hospital environment. This results in repetitive transmission of the data from BANs to MDCs or NSC due to a dead node in its path. The loss of the packet due to the failure of the node results in high bandwidth and wastage of energy. This algorithm improves on energy conservation of the nodes and load balancing within the network by using minimum node participation to forward critical data to the base station. Hence, this technique helps in reducing the overhead caused on the overall network. Extensive simulations in the OMNeT++ based have been performed in order to show the performance of the proposed extensions to the ACO based WBAN routing protocol to handle the critical information to successful transmission without any link failure hence increase the overall network lifetime. Thus we propose a method using the CH-ACO algorithm address the above issues which use to enhance the accuracy of finding the best path selection from source to destination. In our proposed routing protocol, system model is similar to ZK-BAN with initialization values of $\alpha$, $\beta$ and pheromone value to be 1.0. We did simulations for 50 runs on average.

4.1 Clustering technique

The proposed algorithm is a Cluster Head routing protocol and is based on an ANT Colony algorithm. It consists of two ant agents called forward ants and backward ants. Forward ants are basically used to find a path between a source i.e. BANs and to the base station MDCs or NSC. During the route discovery phase a number of ants leaves the source node in search for food. Thus, the task of each ant is to find a route in communicating with the neighbour. They update the routing table of each sensor node while travelling with pheromone left on the trail and the residual energy of each node. During this procedure, the number of nodes grows which leads to overhead explosion. Cluster formation helps to improve the overall performance of the network by data aggregation method, which subsequently balances the load on the network, limited intermediate nodes and increase in network lifetime. Only the cluster head will transmit the data to another cluster head. This helps in energy savings for the nodes in the network and reduces the latency.

Many routing protocols have been proposed based on clustering such as LEACH, TEEN (Threshold Sensitive Energy Efficient Sensor Network Protocol), HEED (Hybrid Energy Efficient Distributed Clustering), PEGASIS (Power Efficient Gathering in Sensor Information Systems) and so on. LEACH routing protocol is very efficient in
Wireless Sensor Network since, all the clusters are self-organized. In each cluster it has one cluster Head and other nodes where they transmit the data to the cluster head. All the clusters in LEACH are self organized hence they are balanced in terms of energy which prolongs the network life time of the network. It consists of two phase called setup phase and steady state phase. In setup phase, clusters are formed and whereas in steady state phase transmission of data takes place. During set-up phase ants generate a random number between 0 or 1 and it compares with the threshold value \( T(n) \). If the number is less than \( T(n) \), the node is elected as cluster head, where the modified threshold \( T(n) \) is as follows:

\[
T(n) = \begin{cases} 
    \frac{p}{1 - p \cdot (r \mod \frac{1}{p})} \cdot \frac{p_{\text{current}}}{p_{\text{initial}}} \cdot \frac{E_{\text{current}}}{E_{\text{initial}}} & \text{if } n \in G \\
    0 & \text{Otherwise}
\end{cases}
\]  

Once MDCs become a cluster head in that terrain, it sends an Hello Packet to all other nodes to join the cluster based on the received signal strength message. All other nodes in the network confirms by joining the cluster. Once upon confirmation, the cluster head allocates the TDMA information to all other nodes in the cluster when to transmit data. The non-cluster head sends the data to the MDCs. Further the cluster head chooses the next cluster head based on the modified probabilistic function until destination is reached. This way it selects the optimal among the cluster heads according to the cost function. It then checks the various routes the ants travel from source to destination through the caves. If the cost function is minimum from the routing table, then it is the optimum path from source to destination. Where \( N \) represents the set of all Cluster Head nodes in the terrain.Routing table has information about the visited list of the nodes traversed. It removes the previous list data from the routing table

\[
\text{Cost function}(i, j) = \min \left( \sum_{i \in N} \text{Cluster Head Probability}(\tau_{ij}) \right)
\]

### 4.2 Forward ANT

This ant helps in finding the best and shortest path by looking up the information stored in neighbour nodes from pheromone tables/routing tables. Initially it forwards Hello Packet to the neighbour nodes as per Table 2. It maintains two distance information; first is the distance between the BAN to its corresponding MDCs and distance between MDCs of one cluster to all other cluster head MDCs from the NSC which is placed at centre of area. It is important for any ant to know the length between any other nodes as shown in Table 3. BANs ID, MDCs ID, and NSC are the identification numbers respectively. \( D_{ij} \) is the distance between BAN to any other node either MDCs or NSC. The pheromone value of each link increases every time as it forward ant crosses through that particular link. The forward ant chooses its next hop based on the route discovery algorithm using ACO in order to reach its destination. The next hop Cluster head is selected based on the modified probabilistic function based on Equation 3. Selection of cluster head with in each cluster is based on the Equation 4

Cluster Head Probability \((t) = \frac{D_{ij} \cdot \alpha + [P_{ij}(t)] \cdot \beta \cdot \tau_{ij}}{\sum_{i=0}^{N} D_{ij} \cdot \alpha + [P_{ij}(t)] \cdot \beta \cdot \tau_{ij}}\)

\[
\text{Cluster Head Probability gives the probability of each node to be next cluster head is as follows:}
\]

\[
P_{ij} = \frac{(\tau_{ij})^\alpha \cdot (\eta_{ij})^\beta}{\sum_{l\in U} (\tau_{lj})^\alpha \cdot (\eta_{lj})^\beta}
\]
Table 4. Hello Packet Structure.

<table>
<thead>
<tr>
<th>Ant.Visitednode</th>
<th>$p_i^{current}$</th>
<th>Hops count</th>
<th>$E_{current}$</th>
<th>Last update time</th>
<th>$D_{ij}$</th>
</tr>
</thead>
</table>

Algorithm 1. Breadth First Search

```
procedure BFS(Position source, Position target)
begin
push source node into currentQueue
source Distance ← get distance between source and target
while true do
  for each node in the currentQueue do
    for node in the currentQueue do
      if BFS next(position, target) < sourceDistance then
        return position;
      end if
    end for
  end if
  if (nextQueue == 0) then
    return position;
  end if
  currentqueue ← 0;
  nextqueue ← nextqueue;
  nextqueue ← 0;
end while
return position;
end procedure
```

4.3 Backward ANT

Upon reaching the destination of the forward ants, the NSC or MDCs extracts and do the processing of the received packet. The destination nodes adds the following information about the source node header, destination data header and stack value and sends it back to the source node in the same path which is trying to adapt the changes in the network. During its transmission, if it occurs any link failure, it is capable of searching for an alternate path by contacting the routing table.

4.4 Implementation of breadth first search technique

If ants placed at wrong position, it is hard for them to find and collect the food in the terrain. This mostly happens when some of the nodes die due to its energy consumption after the transmission which could be failure of a node which results in starvation. This results in reduction in network lifetime of the network. Thus in keeping view of this problem, as a solution we implemented Breadth First Search algorithm in ANT Colony Optimization technique which overcomes the problem of trapping during exploration for the multi-path routing protocols which was not focused. This process use to explore the neighbour nodes i.e. MDCs from source node BANs to destination nodes level by level as per Algorithm 1. This process continues until it finds the specific solution.

4.5 Route discovery

Route Discovery is the process of generating the shortest-minimal energy route between source BAN and destination MDCs or NSC. It uses two types of control packets called forward ant and backward ant. An ant starting from source moves in forward direction is called forward ant and then the same ant returns from destination device to the source BAN is called to be the backward ant. A forward ant establishes an optimal path from BAN to destination MDCs or NSC and the backward ant establishes a pheromone track from MDCs to source BAN, using the path formed by forward ant. A forward ant of a unique sequence number is broadcasted from the source BAN device till it reaches the destination MDC or NSC through intermediate cluster head devices of the network. A forward ant carries a routing
vector that contains intermediate MDC IDs of the route. A device receiving the forward ant, finds its neighbouring nodes using the adjacency matrix of the network and computes probability function values of the connections to find its next cluster head level by level. Then the ant is forwarded to next device of highest probability value connection and adds current device ID to the routing table. When forward ant reaches the destination device, it resends the ant in the backward direction called the backward ant and that follows the routing vector IDs to reach the source. The backward ant deposits the pheromone trial and updates the pheromone value on the connections in the path. Thus a path is established from source BAN to destination MDCs or NSC. Then a path is generated and data can be sent along the path.

Working of this phase is follows:

- Forward ants start from source device and broadcasted to its neighbouring devices using probability function of choosing cluster head based upon the pheromone and energy values at each node until destination is reached.
- Source BAN waits for backward ant. If it has not received within then timeout period, it generates a new forward ant of a new sequence number and broadcast it to its neighbouring devices. If it has received within the timeout period, then a path is established and process is repeated for little iteration based on the formula below to get an optimal path. The count of iterations is calculated based on the equation

$$\text{Iterations count} = 0.5 \times \frac{\text{current iteration number}}{\text{total number of iterations}}$$

(5)

4.6 Route maintenance

Route maintenance phase is responsible for maintaining the path that has been generated and established in the route discovery phase. Whenever data packets are transferred between BANs and destination nodes either MDCs or NSC in the path discovered, the pheromone is incremented in the path between the BAN and the MDCs/NSC (final destination) so that the optimal path obtained in the route discovery phase is sustained. An acknowledgement is sent by the destination BAN to the source for the packets received. If a node doesn’t receive the acknowledgement

```
1: if an ant arrives at node i then
2:    if node i is not a CH then
3:        if there is a CH then
4:            pick a CH neighbor using equation 1
5:            send the ant to it
6:        else
7:            store the ant
8:            broadcast a message regarding the cluster head to all other nodes in the cluster
9:        end if
10:   else
11:       if node i is a CH then
12:          decrement the value of TTL (maximum number of hops) of the ant
13:          if (TTL > 0) then
14:              pick a next cluster head neighbor according to the probability function using equation 3
15:              choose the highest probability function and add current node ID to the routing vector
16:              send the cluster ant to it
17:              Forward the next hop ants
18:          else
19:              destroy the ant
20:          end if
21:      end if
22:  end if
23: end if

Algorithm 2. Tasks Done by the Other Nodes```
Algorithm 3. Updates After Time Expires

1: procedure Update()  
2:     if ant_position ≠ target then  
3:         moveTo(ant_position + target)  
4:     end if  
5:     UpdateType(terrain, cases, foodsources)  
6:     nextMove(terrain, cases, foodsources)  
7: end procedure

Algorithm 4. Route Failure Handling

1: if node is dead then  
2:     if an alternate path exists from the current node to MDC then  
3:         Look at the routing table to send packets through other routes;  
4:     end if  
5:     if packet not reached in time then  
6:         Pheromone ← 0;  
7:     send route failure error message to BAN;  
8: end if

Table 5. Simulations Parameters Information.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>21 m*21 m</td>
</tr>
<tr>
<td>Deployment type</td>
<td>cases 1: Fixed packets \ cases 2: Variable packets</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>49 nodes (24 BANs, 24 MDCs, 1 NSC)</td>
</tr>
<tr>
<td>Initial node energy</td>
<td>18720 J (2 AA batteries)</td>
</tr>
<tr>
<td>Buffer size</td>
<td>32 packets</td>
</tr>
<tr>
<td>Transmit power</td>
<td>−25 dBm, −15 dBm, −10 dBm</td>
</tr>
<tr>
<td>Application type</td>
<td>Event-driven</td>
</tr>
<tr>
<td>Max. packet size</td>
<td>80K packets</td>
</tr>
<tr>
<td>Traffic type</td>
<td>CBR (Constant Bit Rate)</td>
</tr>
<tr>
<td>MAC</td>
<td>IEEE 802.15.4 Default values</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>1000 seconds (average of 5 iterations)</td>
</tr>
</tbody>
</table>

within a timeout period, then a route error message is transmitted to the previous node. This module works as per Algorithm 3.

Route maintenance is also required when the network topology changes with time and also the route between the nodes has to be modified. Whenever there is a change in the network topology, the position of current BANs and MDCs is obtained from the NSC and the route discovery phase is restarted.

4.7 Route failure handling

This phase is responsible in handling route failure cases which generates alternative routes. Every packet is associated with an acknowledgement before the time expires. If a BAN does not receive an acknowledge for a specific packet it has sent, it means that the connection is failed. Once the BAN detects the connection is failed it sends a route error message to the source BAN and terminates and get removes from the routing table by making this path, setting the pheromone value to zero. Now the previous BAN tries to find out an alternate path to reach MDC. If an alternate path exists then the packet is sent to that path as per the Algorithm 4. If an alternate path does not exist then the BAN informs its neighbouring MDC’s to forward the packet back towards the source BAN till it reaches the source BAN. Once the packet reaches the source BAN, the source BAN calls a new route discovery phase. ACO generates multiple paths. Though the optimal path fails, ACO chooses the next best path by considering the next highest pheromone value and maximum residual energy. Thus ACO doesn’t break down on failure of connections.

5. Performance Evaluation and Results

The OMNeT++ based simulator is used to perform the experiments of CH-ACO for WBAN for our proposed protocol. We used two cases for our experiments. Case 1 uses seven nodes with stationary BAN coordinators (BANCs) with fixed packets. The Case 2 is similar to Case 1 but with variable packets that simulates a real hospital. The transmit power used in our experiments is −25 dBm, −15 dBm and −10 dBm for all two cases. The successful transmission rate, overall energy consumption, traffic load are measured for all the two cases. Our proposed routing algorithm performance prove to be better than ZK-BAN as shown in Fig. 2.
Fig. 2. Simulation Results.
6. Conclusions

Wireless Body Area Network is an emerging technology for next generation of health care services. In this paper we proposed a Cluster based Energy efficient ANT Colony Optimization algorithm which is able to find an optimal way of choosing the next hop by clustering process using a modified ANT Colony modified probabilistic function based upon the pheromones and residual energy in each node. Hence, our proposed system monitors the patients data continuously and send to the base station via. Cluster Heads i.e. through MDCs during emergency reasons. We simulated our proposed technique in OMNet++ simulator and have compared with existing system in terms of jitter, latency, energy and throughput and it has been observed that our proposed system has better performance than conventional systems.

References